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COMPUTER-AIDED FINAL DESIGN COST ESTIMATING SYSTEM OVERVIEW.(U)

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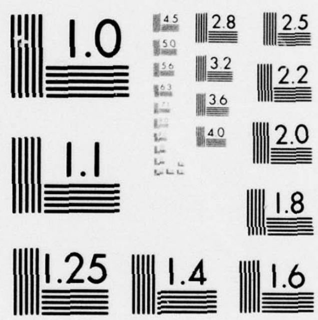

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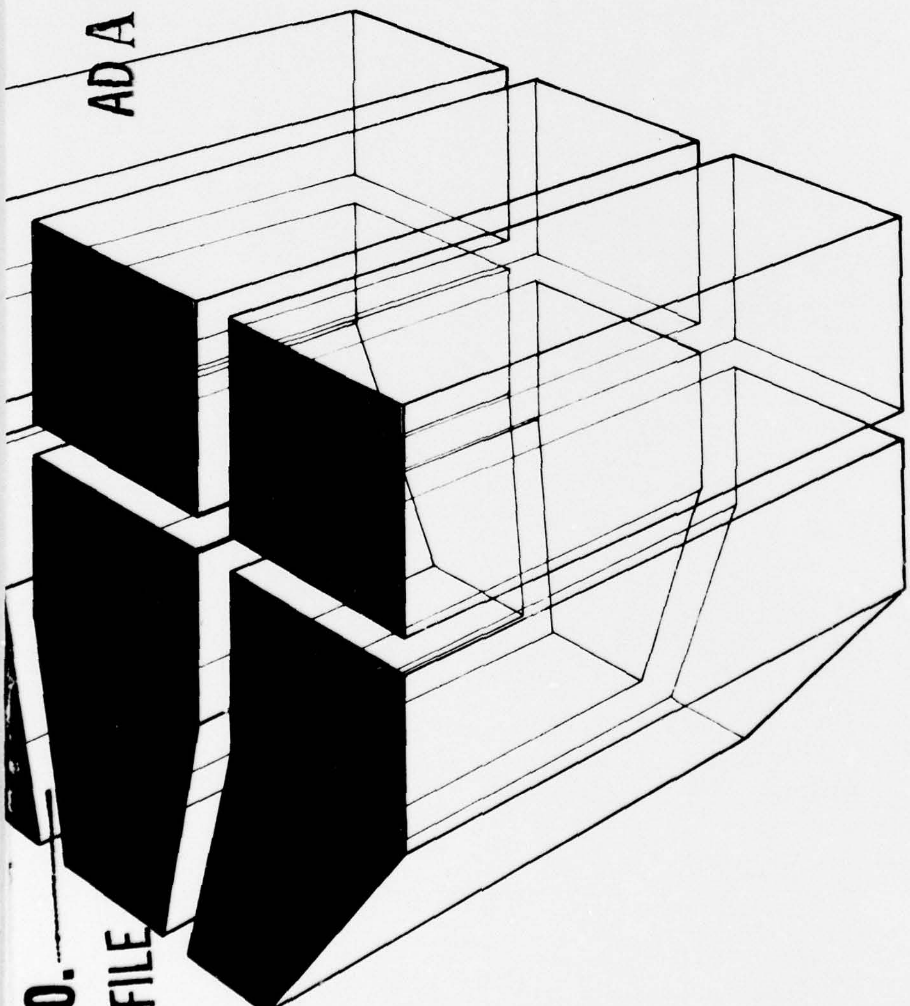
May 1977
Construction Cost Estimating System

COMPUTER-AIDED FINAL DESIGN COST ESTIMATING SYSTEM OVERVIEW



by
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This report presents an overview of a proposed computer-aided final design cost estimating system that will help cost estimators prepare final design construction cost estimates. Use of the system and the cost estimating concepts on which the system is based are discussed. Data development and maintenance strategies are proposed.

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FOREWORD

This research was conducted for the Directorate of Military Construction, Office of the Chief of Engineers (OCE), under Project 4A76279AT41, "Design, Construction, and Operations and Maintenance Technology for Military Facilities"; Task 01, "Development of Automated Procedures for Military Construction and Facility Engineering"; Work Unit 005, "Construction Cost Estimating System." The applicable QCR is 3.03.003. The OCE Technical Monitor was Mr. Ronald J. Hatwell.

The work was performed by the Management Systems Branch (FAM), Facility Acquisition and Construction Division (FA), U.S. Army Construction Engineering Research Laboratory (CERL), Champaign, IL. The Principal Investigator was Mr. Michael J. O'Connor. Dr. Omar E. Rood, Jr. is Chief of FAM, and Mr. E. A. Lotz is Chief of FA.

COL J. E. Hays is Commander and Director of CERL and Dr. L. R. Shaffer is Technical Director.

CONTENTS

COMPUTER-AIDED FINAL DESIGN COST ESTIMATING SYSTEM OVERVIEW

1 INTRODUCTION

Background

Construction is the process of converting labor, material, and equipment into buildings. Cost estimating is the process of estimating the cost of construction prior to its accomplishment. The government estimate, which is required for all new Military Construction projects and for modifications over $25,000, is a detailed estimate prepared after design is completed. This estimate serves three main purposes:

1. To determine the fair and reasonable cost to the Government for performing the work by construction contract

2. To evaluate bids and identify possible bidding errors

3. To aid in determining intermediate progress payments to the construction contractor

To meet these objectives, an estimate must be complete (i.e., include all construction tasks required to construct the building), accurate (i.e., free of arithmetic errors), and presented in sufficient detail and in a format that clearly indicates the thoughts and judgments of the estimator. Developing an estimate which meets these criteria requires the estimator to perform a number of routine tasks as well as exercise professional judgment. Computer assistance with routine calculations, storage, and retrieval of cost estimating data would free the estimator to concentrate more on the professional judgment aspects of cost estimating.

Objective and Scope

The objective of this study is to develop a computer-aided cost estimating system to help cost estimators prepare detailed final design construction cost estimates. It is not the intent of this work to completely automate the preparation of cost estimates, because the most important element of any estimate—the professional estimator's experienced judgments about the specific project under consideration—cannot be programmed. This report provides an overview of the proposed system.

Approach

The repetitive nature of the construction tasks required to build typical Military Construction projects provides the basis for the proposed computer-aided final design cost estimating system which is described in Chapter 2. A Task Cost Guide, a master list of commonly encountered construction tasks with unit costs, will be developed based on this principle. The Task Cost Guide will be organized by building systems and subsystems to provide the degree of standardization necessary to compare different project estimates and to provide a vehicle for passing on the experience of professional estimators. Chapter 3 presents proposed data development and maintenance procedures for the Task Cost Guide.

2 USE OF THE COMPUTER-AIDED COST ESTIMATING SYSTEM

General

The computer-aided cost estimating system will be used in four phases:

1. Quantity survey. The user performs the quantity survey and transfers the results to the computer-aided cost estimating system.

2. "First-pass cost estimate. The computer-aided cost estimating system develops a "first-pass" construction cost estimate from the user-supplied quantity survey and the computer-resident Task Cost Guide.

3. Cost engineering. The user performs a cost engineering review and analysis of the most cost-significant tasks. The adjustments made during cost engineering analysis will result in a final estimate that is tailored to the anticipated project-specific conditions.

4. Final cost estimate. The computer-aided cost estimating system produces the final cost estimate.

The following sections detail how the four phases will be performed when the system is operational.

Quantity Survey

The user will perform the quantity survey (takeoff) manually for each required construction task, using the Task Cost Guide as a checklist to insure that all required construction tasks are included in the estimate. The user will then input the results of the quantity survey (i.e., required tasks with quantities) via remote terminals (on-line mode) or keypunched cards (batch mode).

On-line input will be supported by allowing the user to interactively scan the Task Cost Guide and post task quantities against each required task. Interactive scanning allows the user to look at only those portions of the Task Cost Guide that are applicable to the specific project under consideration. Input will be accomplished by typing the task identification number, unit of measure, and required quantity on the remote terminal keyboard for each required construction task.

Batch input will be provided for large volume input. In this mode, the quantity surveyor will use a hard copy of the Task Cost Guide to identify tasks and will write the task number, unit of measure, and required quantity for each required construction task on keypunch forms. The cards will be keypunched and loaded on the computer.

For tasks required in the project but not included in the Task Cost Guide, the estimator may either (1) select a related task for development of the "first-pass" cost estimate and adjust the related task as necessary during the cost engineering phase, or (2) define a new user task for this project estimate.

"First-Pass" Cost Estimate

The computer-aided cost estimating system will calculate a "first-pass" cost estimate based on the task quantities from the quantity survey and task unit costs from the Task Cost Guide. This "first-pass" estimate will be calculated by extending the task unit costs times the quantities and summing over all tasks.

Several ways of presenting the "first-pass" cost estimate to the cost estimator will be provided. The user will be able to request cost reports formatted by descending order of task cost, by building systems, and by construction trade categories. The estimator will also be able to specify the level of detail in which the task costs are reported. The most detailed level of task cost reporting will display the detailed derivation of the task unit cost from its basic elements of task productivity, labor, material, and equipment requirements and rates, and the total extended task cost. The summary level of task cost reporting will display the task unit cost by labor, material, and equipment unit cost components, and the total extended task cost.

Cost Engineering

Cost engineering is the application of experienced professional judgment to the analysis and estimation of construction costs. The most reasonable way to conduct this analysis is in the same terms as the construction itself is performed; i.e., through the analysis of construction tasks that are defined in terms of the basic construction elements of labor, material, and equipment. Since construction projects consist of a large number of tasks, detailed analysis and development of task costs from scratch for each individual task would be prohibitively expensive. Fortunately, two factors make this unnecessary.

First, all tasks are not equally significant; minor changes to tasks with small quantities and unit costs will not have the same impact on the total estimated cost of the project as minor changes to tasks with large quantities and unit costs. The 80/20 rule, a rule of thumb that has been found valid in a number of business applications, describes this distribution of cost significance. This rule, when applied to cost estimating, states that 80 percent of the total estimated cost of a typical project is accounted for by 20 percent of the required tasks.

Second, the repetitive nature of construction allows predefinition of tasks under the assumption of "normal" construction conditions and "average" costs for labor, material, and equipment to a degree of "accuracy" that is sufficient for the less significant tasks within the total project. Since the 80 percent of tasks that account for only 20 percent of the total cost will typically include a relatively large number of tasks, the minor errors will tend to balance out.

Hence, cost engineering refinement can be practiced by analyzing and adjusting the most significant tasks in the project. The "first-pass" estimate provides the necessary perspective for determining the significance of each individual task to the total estimated project cost. Using the appropriate presentations of the "first-pass" estimate, the cost estimator can review the detailed development of the task unit cost for the most significant tasks; these tasks might, for example, be defined as those costing over $5,000 or 2 percent of the total estimated project cost.

This review will acquaint the estimator with the assumptions used in developing the "first-pass" task costs. To tailor the "first-pass" estimate to a project-specific final estimate, the estimator must know these assumptions and be able to change any or all of them. The system will allow the estimator to adjust the task productivity and the labor, material, and equipment requirements from "normal" construction conditions to the appropriate values under the anticipated project-specific conditions. The estimator will also be able to review and adjust labor, material, and equipment rates. For instance, the estimator could replace the "average" regional rate of high cost/quantity materials with direct vendor quotes.

This same analysis can be applied to any task whose unit cost the estimator feels may be wrong. Additional tasks of lesser cost significance can also be analyzed if time permits.

The computer-aided system will support the cost engineering review and data adjustment interactively, allowing the user to control the information and level of detail that is displayed. The system will also provide the estimator with immediate feedback on the results of adjustments by recalculating and displaying the new total estimated cost.

Final Cost Estimate

The final estimate is the estimate of the total project cost after all cost engineering is completed. The computer-aided cost estimating system will allow the estimator to structure the cost estimate by prime and subcontractor work, and will have provisions for including cost estimates for general conditions, overhead, and profit. This structuring of the estimate will facilitate evaluation of contractors' bids.

3 DATA DEVELOPMENT, ORGANIZATION, AND MAINTENANCE

Data Development

The Task Cost Guide will be composed of construction tasks defined in terms of the labor, material, and equipment required to perform the construction operation. Figure 1 shows an example task definition. For this example, it was estimated that under "normal" construction conditions, a roofing crew of seven roofers would place 13.0 squares of hot asphalt membrane roofing per hour and would require a roofing hoist and kettle 100 percent of the placement time. It was also assumed that 1.11 squares of felt and 35 lb (16 kg) of asphalt are required for each "in-place" square of roof covering. This means that on the average, 0.11 squares or 11 percent of felt per square of roof covering are lost through cutting waste, etc., and that the asphalt is sprayed at a nominal rate of 35 lb (16 kg) per square.

The Task Cost Guide will contain task unit costs calculated as shown in Figure 2. For this example, the labor, material, and equipment rates shown were assumed to represent reasonable "average" rates for the geographical region of interest. The calculation is a straightforward extension of requirements and rates. The resultant task unit cost is $10.92 per square of asphalt felt membrane; this total is composed of $5.10 labor unit cost, $5.30 material unit cost, and $0.52 equipment unit cost.

Based on the intended use of the Task Cost Guide (calculation of a "first-pass" estimate), the 80/20 rule, and existing commercial task cost guides, it is estimated that approximately 15,000 construction tasks will provide reasonable coverage of the most commonly encountered tasks for Military Construction projects. (Means[1] includes over 17,000 unit prices, Dodge[2] has approximately 10,000, and the Building Cost File[3] contains approximately 15,000 construction items.)

It is further estimated that approximately 200 labor, 15,000 material, and 1000 equipment items will support the 15,000 construction tasks. Labor, material, and equipment rates can be determined for as many geographical regions as desired to provide for the calculation of regionalized Task Cost Guides.

Corps of Engineers cost estimators should be actively involved in identifying and defining the construction tasks for the Task Cost Guide to insure that the appropriate tasks, defined in accordance with Corps Guide Specifications, are included. Determination of the labor, material, and equipment rates, while time consuming, is relatively routine.

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[1] *Building Construction Cost Data*, 34th annual edition (Robert Snow Means Company, Inc., 1976).

[2] *Dodge Manual for Building Construction Pricing and Scheduling*, 11th annual edition (Dodge Building Cost Services, 1976).

[3] *Building Cost File: 1976 Unit Prices Central Edition*, 5th annual edition (Construction Publishing Company, Inc., 1976).

TASK DESCRIPTION	TASK UNITS	TASK PRODUCTIVITY (TASK UNITS/CREW HOUR)	TASK PRODUCTIVITY (MAN HOURS/TASK UNIT)
ASPHALT FELT MEMBRANE-30 lb/sq SPRAYED HOT ASPHALT BONDING	SQ	13.0	0.54

LABOR:	CREW COMPOSITION (MAN HOURS/CREW HOUR)
ROOFER FOREMAN	1
ROOFER	4
ROOFER KETTLE MAN	1
ROOFER APPRENTICE	1

MATERIAL:	MATERIAL UNITS	MATERIAL REQUIREMENTS (MAT'L UNITS/TASK UNIT)
30 lb. ASPHALT FELT	SQ	1.11
ASPHALT	LB	35.00

EQUIPMENT:	EQUIPMENT UTILIZATION (EQUIP. HOURS/CREW HOUR)
ROOFING HOIST	1.00
KETTLE-165 GAL. CAP.-SPRAY EQUIP.	1.00

Figure 1. Example task definition.

TASK DESCRIPTION	TASK UNITS	TASK PRODUCTIVITY (TASK UNITS/CREW HOUR)	TASK PRODUCTIVITY (MAN HOURS/TASK UNIT)
ASPHALT FELT MEMBRANE-30 lb/sq SPRAYED HOT ASPHALT BONDING	SQ	13.0	0.54

LABOR:	CREW COMPOSITION (MAN HOURS/CREW HOUR)		LABOR RATE ($/MAN HOUR)		LABOR COST ($/CREW HOUR)		TASK PRODUCTIVITY (TASK UNITS/CREW HOUR)		LABOR UNIT COST ($/TASK UNIT)
ROOFER FOREMAN	1	x	10.28	=	10.28				
ROOFER	4	x	9.78	=	39.12				
ROOFER KETTLE MAN	1	x	9.78	=	9.78				
ROOFER APPRENTICE	1	x	7.06	=	7.06				
					66.24	÷	13.00	=	$5.10

MATERIAL:	MATERIAL UNITS	MATERIAL REQUIREMENTS (MAT'L UNITS/TASK UNIT)		MATERIAL RATE ($/MAT'L UNIT)		MATERIAL COST ($/TASK UNIT)		MAT'L UNIT COST ($/TASK UNIT)
30 lb. ASPHALT FELT	SQ	1.11	x	2.25	=	2.50		
ASPHALT	LB	35.00	x	0.08	=	2.80		
						5.30	=	$5.30

EQUIPMENT:	EQUIPMENT UTILIZATION (EQUIP. HOURS/CREW HOUR)		EQUIP. RATE ($/EQUIP. HOURS)		EQUIP. COST ($/CREW HOUR)		TASK PRODUCTIVITY (TASK UNITS/CREW HOUR)		EQUIP. UNIT COST ($/TASK UNIT)
ROOFING HOIST	1.00	x	2.30	=	2.30				
KETTLE-165 GAL. CAP.-SPRAY EQUIP.	1.00	x	4.50	=	4.50				
					6.80	÷	13.00	=	$0.52
							TASK UNIT COST		$10.92/SQ

Figure 2. Example task unit cost calculation.

Data Organization

The Task Cost Guide will be organized in accordance with the UNIFORMAT, which is a structure that breaks buildings into major systems, systems into subsystems, etc. The UNIFORMAT will provide the estimator with a uniform format for preparing and checking final design estimates. In addition to providing uniformity and supporting the quantity survey by providing a checklist to insure that all the tasks required to construct a system are included in the project estimate, the systems approach is highly compatible with construction network scheduling and with measurement of job progress for intermediate payment. The UNIFORMAT also supports accumulation of historical costs of past projects on a building systems basis for use in preparing future project estimates.

Table 1 shows the 16 UNIFORMAT systems. Table 2 shows how the Roofing system is divided into seven subsystems, which are further subdivided. The task defined in the previous section–asphalt felt membrane–would appear under Membrane Roofing within the Roof Coverings subsystem of the Roofing system.

Table 1

UNIFORMAT Systems

BUILDING:

01 – SUBSTRUCTURE
02 – STRUCTURAL FRAME
03 – ROOFING
04 – EXTERIOR WALLS
05 – INTERIOR WALLS
06 – INTERIOR FINISHES
07 – SPECIALTIES
08 – PLUMBING
09 – HVAC
10 – SPECIAL MECHANICAL SYSTEMS
11 – ELECTRICAL
12 – SPECIAL ELECTRICAL SYSTEMS
13 – EQUIPMENT AND CONVEYING

SITEWORK:

14 – SITE PREPARATION
15 – SITE IMPROVEMENTS
16 – SITE UTILITIES

Table 2

UNIFORMAT Roofing System

03 ROOFING
- 1 ROOF COVERINGS
  - 1 MEMBRANE ROOFING
  - 2 SHINGLES & ROOFING TILE
  - 3 PREFORMED ROOFING PANELS
- 2 TRAFFIC TOPPING & PAVING
  - 1 ELASTIC SHEET SURFACE MEMBRANES
  - 2 FLUID APPLIED SURFACE MEMBRANES
  - 3 WATERPROOFING MEMBRANES BELOW PAVING
  - 4 SLATTED ROOF DECKS & WALKWAYS
- 3 ROOF INSULATION & BARRIERS
  - 1 VAPOR BARRIERS
  - 2 ROOF & DECK INSULATION
- 4 FLASHINGS & TRIM
  - 1 ROLLED TYPE
  - 2 PREFORMED TYPE
  - 3 EXPANSION JOINTS & COVERS
- 5 GUTTERS & DOWNSPOUTS
  - 1 GUTTERS
  - 2 DOWNSPOUTS
  - 3 ACCESSORIES
- 6 MISC. ROOF SPECIALTIES
  - 1 SNOWGUARDS
  - 2 ROOF RAILINGS
- 7 ROOF OPENINGS
  - 1 SKYLIGHTS
  - 2 HATCHES
  - 3 GRAVITY ROOF VENTILATORS

Data Maintenance

Centralized maintenance of the Task Cost Guide is proposed to insure orderly evolution of the system. Monitoring the Corpswide use of the Task Cost Guide will indicate which tasks have become obsolete and should be dropped and what new tasks are required. Economy of effort can also be realized by centralizing some of the data maintenance. Centralized maintenance of labor rates is not proposed, since there are relatively few labor items and individual Corps Districts have the rate information readily available through their Davis-Bacon wage surveys. Centrally maintaining the material rates for one base location in the country–for example, Washington, DC–is proposed. Translating the base location rates to other geographical regions by using location adjustment indices will save effort and provide sufficiently accurate rates for the less significant tasks.

The central office should continually update the "average" material rates for the base location to maintain the degree of accuracy necessary for the "first-pass" estimate. The "average" material rate should be determined from three to five direct vendor quotes. Assuming 15,000 material items and 250 workdays per year, semiannual updating would require that an average of 120 material items be updated daily. It is esti-

mated that this method of maintaining material rates will require approximately 2 man-years of effort per year. This maintenance could be accomplished by in-house central office effort or by contract effort.

The location adjustment indices should be developed and maintained by material categories. The 15,000 material items should be categorized into approximately 50 categories, with a lead material item identified for each category. Location adjustment indices for each material category would be determined by dividing the "average" lead material rate for the project location by the "average" lead material rate for the base location. Each District could maintain as many sets of location adjustment indices as desired by updating the 50 lead material rates as required.

Maintenance of equipment rates in a similar manner is proposed. The central office should determine base location rates semiannually for the 1000 equipment items in accordance with the procedures contained in the Construction Equipment Cost Guide.[4] Location adjustment indices based on equipment-related costs such as fuel and tire costs should be developed by each District as required.

4 CONCLUSIONS

The proposed computer-aided final design cost estimating system described in this report will help cost estimators prepare detailed final design construction cost estimates by freeing them from routine tasks, thus allowing them to concentrate on the professional aspects of cost estimating. The system takes advantage of the repetitive nature of construction tasks and the 80/20 rule of cost distribution. The system will support good cost engineering practices by generating a "first-pass" estimate that includes the documentation of imbedded assumptions, and by providing the estimator with the capability to change any or all assumptions. The Task Cost Guide can be maintained with current regionalized costs through centralized updating of base location rates and location adjustment indices.

[4] E. Neely, *Construction Equipment Cost Guide*, Technical Report P-52/ADA016788 (U. S. Army Construction Engineering Research Laboratory, 1975).

REFERENCES

Building Construction Cost Data, 34th annual edition (Robert Snow Means Company, Inc., 1976).

Building Cost File: 1976 Unit Prices Central Edition, 5th annual edition (Construction Publishing Company Inc., 1976).

Dodge Manual for Building Construction Pricing and Scheduling, 11th annual edition (Dodge Building Cost Services, 1976).

Neely, E., *Construction Equipment Cost Guide*, Technical Report P-52/ADA016788 (U.S. Army Construction Engineering Research Laboratory, 1975).

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